

First LHCb Results from 2009 LHC Run

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Abstract. At the end of 2009, the Large Hadron Collider (LHC) provided a short run of pp collisions at a centre-of-mass energy of $\sqrt{s} = 900$ GeV. The LHCb Experiment collected its first collision data with the aim of finalizing the commissioning of the detector and perform the spatial and time alignments. This paper presents a collection of preliminary results of the LHCb detector obtained with the data acquired in this first LHC run. A brief outlook of the physics expected with the first data in 2010 at 7 TeV centre-of-mass energy is also presented.

1. Introduction

The LHCb Experiment is dedicated to the precise reconstruction of B decays and the study of CP violation in the b -quark sector. The angular acceptance of the LHCb detector, 10 to 300 mrad, was chosen because in high energy hadronic collisions the majority of $b\bar{b}$ pairs are produced at low angles with respect to the collision axis. The LHCb detector is composed of several subsystems. Closest to the interaction region there is a micro-strip silicon detector dedicated to the reconstruction of primary and displaced vertices, called the Vertex Locator (VELO). The is VELO built in two separate detector halves that retract to a fully open position, when the LHC beams are being injected, and close around the interaction region when the LHC beams become stable. The two most upstream stations in each VELO half constitute the Pile-Up System (PUS) that is very similar to the VELO stations, but the PUS can read out ever bunch crossing (at 40 MHz) and hence are able to participate in the first level of the trigger. Hadron species can be distinguished by two Ring Imaging Cherenkov detectors (RICH) that provide excellent particle identification from 2 to 100 GeV/c. Calorimetry is provided by a fast response Calorimeter system (CALO), composed of a Pre-Shower (PS), a Scintillating Pad Detector (SPD), the Hadron CALorimeter (HCAL) and the Electromagnetic CALortimeter (ECAL), that participates in the first level (hardware) of trigger. The tracking system is built with two different technologies, straw tube gas detectors in the lower occupancy regions (Outer Tracker, OT) and silicon micro strip detectors in the higher occupancy ones (Silicon Tracker, ST) that together with the magnet dipole gives very good momentum determination. The muon system composed of five stations to provide an excellent muon identification and also participates in the first trigger level. The LHCb detector is fully described in [1].

2. Trigger configurations

In the 2009 pilot run the beam intensities and bunch filling were far lower than the nominal values for the LHC. A minimum bias trigger scheme was set up in order to record every collision. It required at least one cluster above threshold (240 MeV) in the HCAL and at least three SPD cells with a hit. In addition to the pp trigger, a beam gas trigger based on the filling scheme

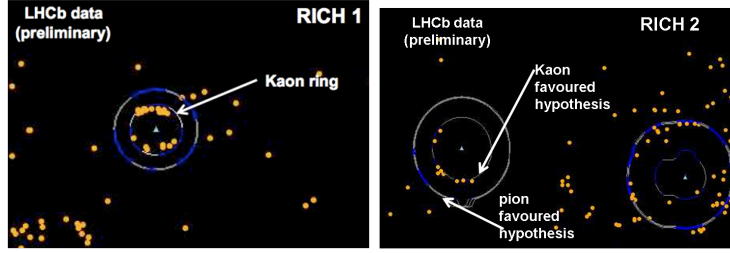


Figure 1. Event display showing the reconstruction of rings in the RICH1 (left) and RICH2 (right). The smaller rings are consistent with the Kaon hypothesis, as shown in the picture.

and the information from either the PUS or the HCAL+SPD decisions was also used. Since the LHCb Detector is designed as a single-arm spectrometer, beam gas events coming from $-z$ ¹ can only be triggered by the PUS. There were three distinct event types recorded: beam1-gas with the beam coming from $+z$ direction, beam2-gas with the beam coming from the $-z$ direction, and collision (or beam-beam).

3. General performance of the sub-detectors

The first LHC run for physics started at the beginning of December 2009 and lasted for approximately two weeks. During that period, the LHCb detector operated with all sub-detectors powered and the magnetic field at its nominal operational value. The VELO collected data in a retracted position, 15 mm away from the nominal closed position² due to the larger beam aperture at 450 GeV energy per beam. Around 300 thousand pp inelastic collisions events, corresponding to an integrated luminosity of $L_{int} = 6.8 \pm 1.0 \mu\text{b}^{-1}$, were acquired in the standard 2009 configuration which are useful for physics analyses.

The statistical sample of 2009 was not large enough to align fully the mirrors of the RICH system nor to complete the time alignment of the photo-multipliers (the RICH uses HPDs [1]). However the first data were sufficient to start these studies as a preparation for the 2010 run. In the run of 2009 it was also possible to measure the first kaon “rings” in the RICH system, and an example is shown in Figure 1.

The CALO proved to be reliable and efficient in the run of 2009. One of the greatest accomplishments of the calorimeter group on LHCb was to time align the four detector systems with a precision better than 2 ns, which is vital due to its function in the trigger. The CALO performs a few functions in LHCb besides participating in the trigger: it provides the electron-photon separation and their measured position and energies; at the trigger level it selects events with a high P_T hadron arising from B decays. As can be seen in Figure 2, already in the 2009 run the calorimeter calibration was good enough to enable a clear π^0 signal to be isolated.

Although not in the nominal closed position the VELO vertex reconstruction performs reasonably well. The Figure 3 shows the beam profile in the xz and yz planes measured with protons colliding to the residual gas inside the beam pipe.

4. V^0 Reconstruction

The first data were used to reconstruct V^0 particles such as K_S^0 and Λ^0 for the first time in the 2009 run. Figure 4 shows the K_S^0 and Λ^0 mass peaks and compares the reconstruction of K_S^0 with and without VELO tracks. The mass resolution will improve with the alignment constants that are produced for the first time with the whole detector. Since the conference LHCb has

¹ The $-z$ direction points from the Muon System towards the VELO, parallel to the beam axis.

² It means that the difference between the halves was equal to 30 mm.

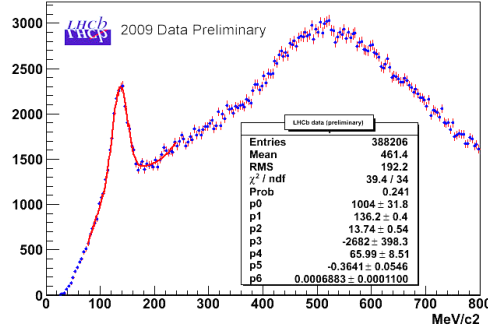


Figure 2. The plot shows the mass reconstructed using photons in the ECAL. The π^0 peak is fitted to a Gaussian function on top of a polynomial background. The mean of the peak is of 136 ± 0.4 MeV consistent with the mass listed in [3].

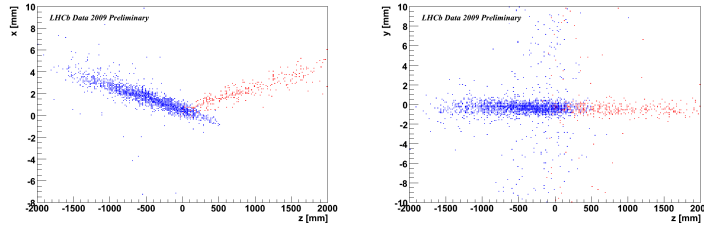


Figure 3. The beam profiles in the xz (left) and yz (right) planes (LHCb coordinates) reconstructed using beam-gas events. The blue (red) points in the plot show the reconstructed vertex positions for beam1(2)-gas interactions.

produced preliminary results on the differential cross-section of K_S^0 production using these data [2].

5. Prospects for 2010-2011

The LHC plans to provide 1 fb^{-1} integrated luminosity at the centre-of-mass energy of $\sqrt{s} = 7 \text{ TeV}$ in the run starting in 2010. For this amount of statistics the LHCb detector has an intensive physics programme [4]. Among many other measurements there are the following key goals: precise measurement of ϕ_s with $B_s^0 \rightarrow J/\psi \phi$ decay; perform a measurement of the forward-backward asymmetry A_{FB} with the $B^0 \rightarrow K^{*0} \mu^+ \mu^-$ channel; make a precise measurement of the CKM phase γ from tree dominated processes; probe for super-symmetry with the measurement of the branching ratio of the rare decay $B_s^0 \rightarrow \mu^+ \mu^-$. For the decay, $B_s^0 \rightarrow \mu^+ \mu^-$, the Standard Model predicts a very precise branching fraction: $3.55 \pm 0.33 \times 10^{-9}$ [5]. Current searches in the Tevatron made by the CDF and D0 collaborations set already a few upper limits as reported in [6]. Many new physics models (like super symmetry) can generate higher branching ratios slightly below the 10^{-8} region which the LHCb detector should be able to measure a first evidence with approximately 1 fb^{-1} , as shown in the plot of Figure 5. The precise measurement of this branching fraction can be made as more statistics are gathered over the following years.

6. Conclusions

The LHCb detector had a very fruitful first run in 2009. All the sub-systems have proved to be ready to acquire data and coherently reconstruct events including decaying particles. The

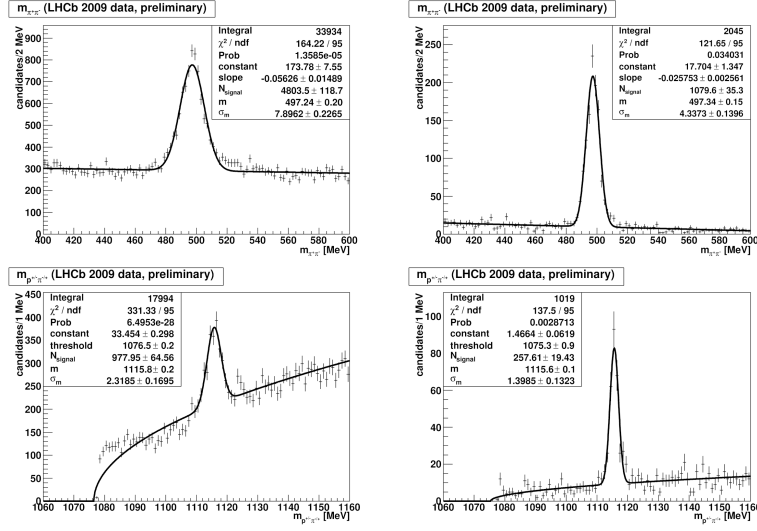


Figure 4. The K_S^0 (top) and Λ^0 (bottom) mass reconstructed using all available tracks (left) and with tracks that have a VELO segment (right). The mass indicated in the plots is compatible with the best measurements listed in [3], noting that with the use of VELO tracks the mass resolution improves by more than a factor 2.

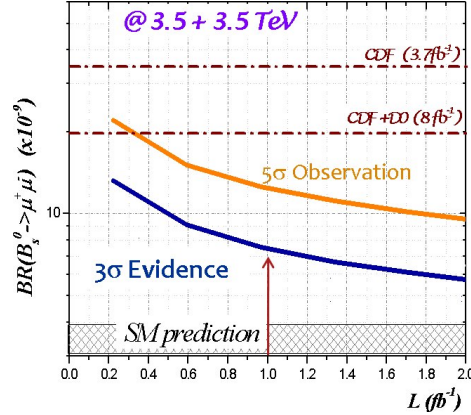


Figure 5. Prospects for the branching ratio measurement of the $B_s^0 \rightarrow \mu^+ \mu^-$ decay channel as a function of integrated luminosity.

first data in 2009 allowed the sub-detectors to perform their calibration and (time) alignment adjustments, finalizing the LHCb commissioning. The 2010-2011 run is eagerly expected, in which the LHCb experiment will be able to show its first B-physics results.

References

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